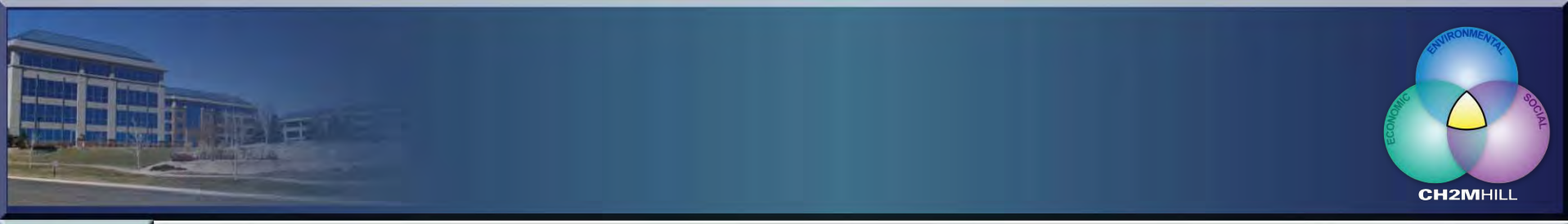

Incorporating Sustainability Impacts into Remediation Feasibility Studies – Is Groundwater Over Valued?

Doug Downey, PE

CH2M HILL

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Overview








- CERCLA Remedial Decision Making
- Green or Sustainable Remediation
- Sustainable Remediation Meets CERCLA
- Incorporating Sustainability into Feasibility Studies
  - Site CS-10 Massachusetts Military Reservation
  - Hill AFB Sustainability Inventory
- What is Needed?

CERCLA Decision Making








Remedial alternatives are evaluated and scored using nine criteria:

- Compliance with ARARs
- Overall Protection of Human Health and Environment

- Short Term Effectiveness
- Long-Term Effectiveness and Permanence
- Reduction in Toxicity, Mobility, and Volume
- Implementability
- Cost

- State Acceptance
- Community Acceptance

CERCLA Decision Making








- Primary focus has been on site-specific contaminants in soil and groundwater and how to remove them
- Secondary focus has been on remediation timeframe and present worth costs
- Regulators and responsible parties are often constrained by regulations requiring high levels of groundwater cleanup regardless of the production value of the aquifer
- Result is that “net environmental benefit” has received little attention or “lip service” at best

Drivers for Sustainable Remediation








- Public awareness
  - Imbalance of rate of growth and consumption of natural resources
- Energy Policy Act of 2005 and Executive Order 13423
  - Requires Federal agencies to utilize minimum renewable energy resources
    - 1.5% from 2007 through 2009
    - 2.5% from 2009 to 2013
    - 3.75% from 2013+
- Pending climate change legislation
  - GHG reporting regulations
  - Cap and trade system
- EPA's Green Remediation

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Sustainability Assessment Framework








Domain

Category

CH2M HILL Sustainability Assessment Framework (SAF)		
ENVIRONMENTAL	**ECONOMIC**	**SOCIAL**
Energy	Cost	Equity
Climate Change	Return on Investment	Aesthetics
Transportation/Land Management	Liabilities	Justice
Water	Assets	Health and Safety
Materials Use/Waste	Economic Development	
Biodiversity/Habitat	Life Cycle	

Over 200 sustainability criteria behind these categories

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EPA's Green Remediation Primer – April 2008








- Defines Sustainable or Green Remediation

- Core Elements of Green Remediation
  - Reduced energy requirements (renewable energy push)
  - Reduced air emissions
  - Minimize fresh water consumption/degradation
  - Non-invasive remedies – favors in situ methods
  - Minimize waste and maximize recycling
  - Produce a net environmental benefit

How Does This Change Remediation?








- Focus is on making existing systems more sustainable
  - Optimization to reduce energy and waste
  - More use of renewable energy sources
  - Favors in situ, low-energy remedies for new sites
- Encourages incorporating sustainability impacts into remedial decision making, but provides no clear guidance on how to do this
- No mention of revisiting existing RODs to switch to more sustainable remedies

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Can CERCLA and "Green" Mesh?







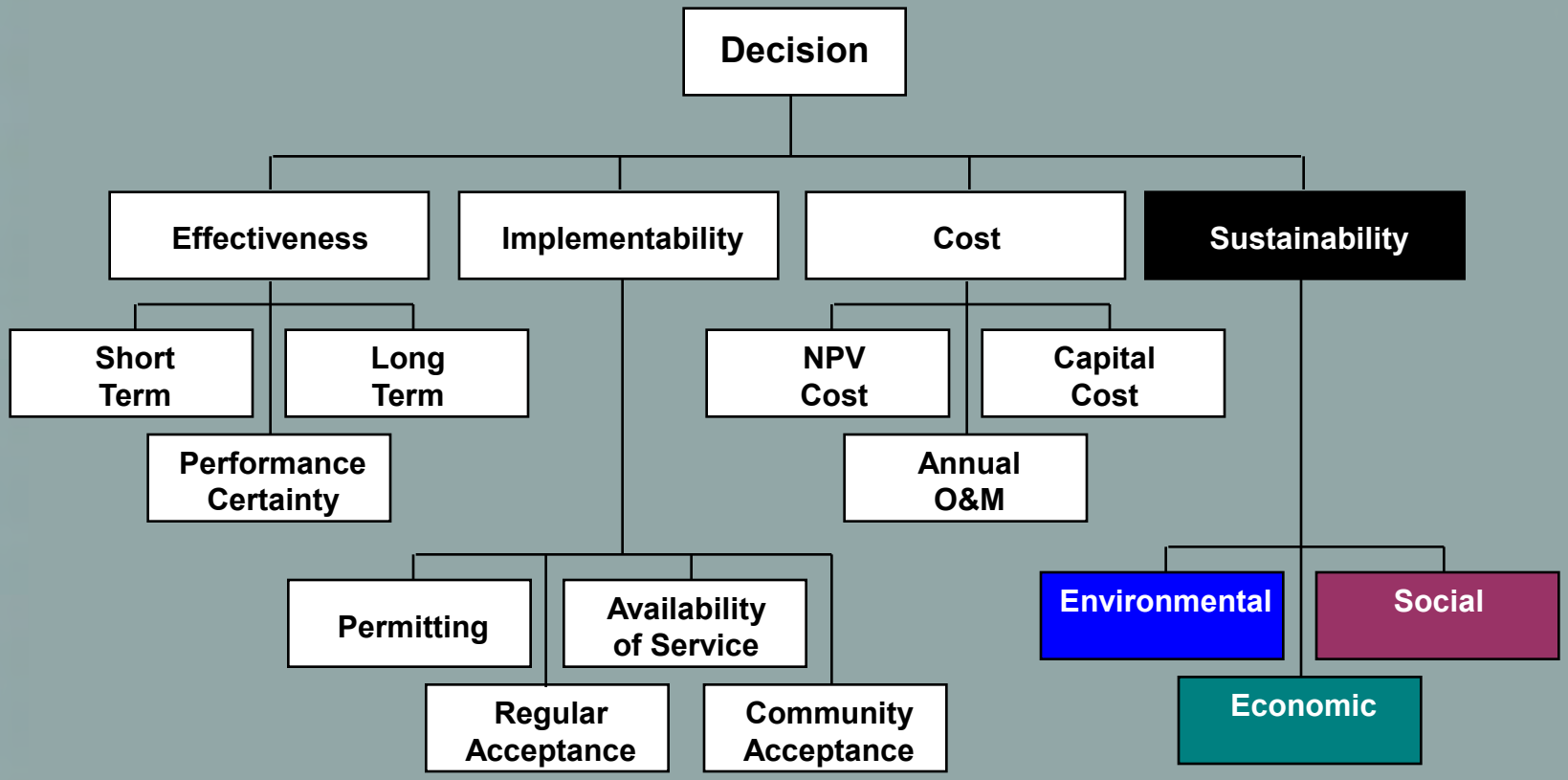

- Add sustainability as a new 10th criteria?
- Add emphasis to short-term effectiveness?
- Promote and streamline ROD amendments that switch to more sustainable technologies
- Rewrite CERCLA guidance to promote a more holistic approach to environmental protection

Sustainability Equal with Other Decision Factors







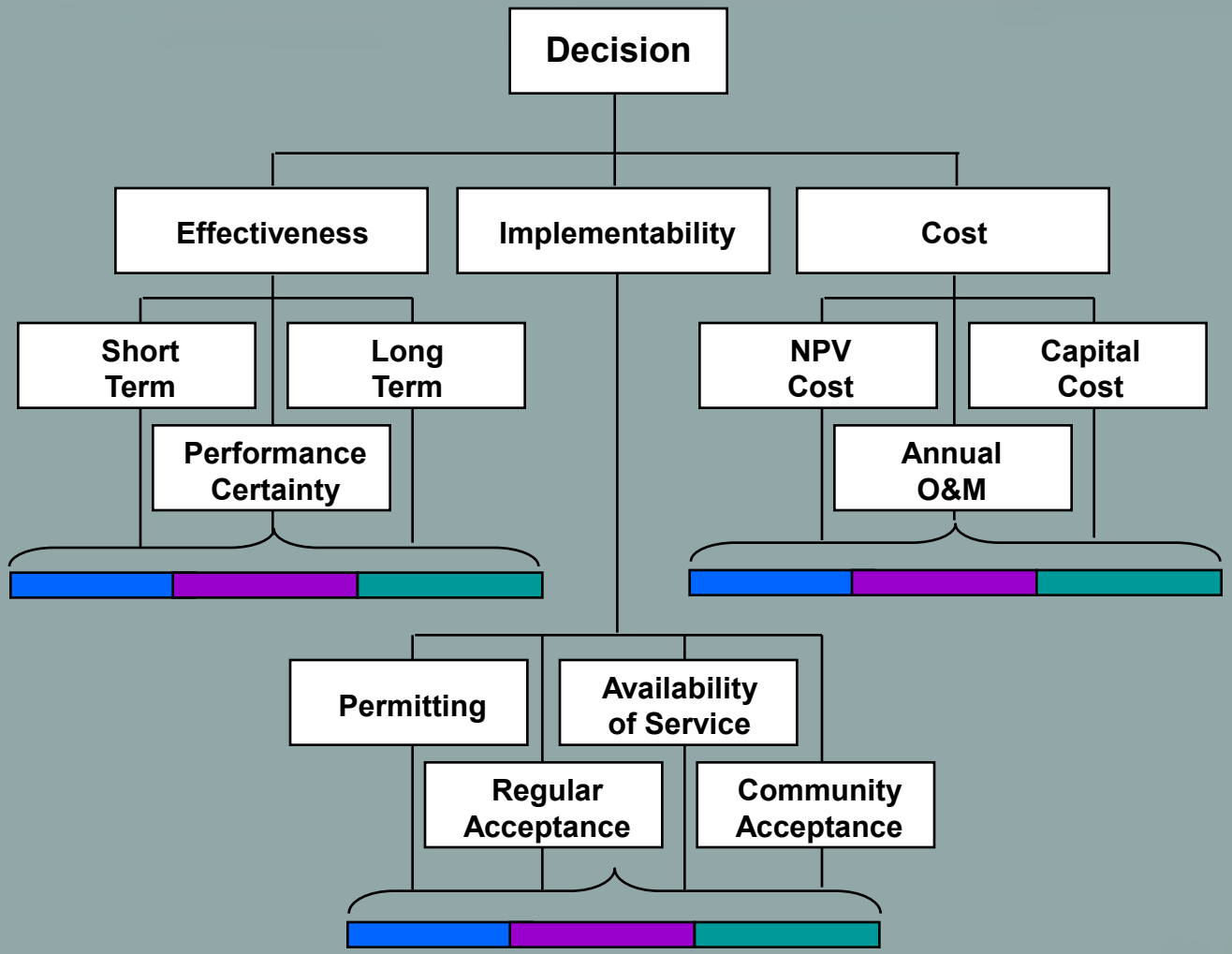
= Decision factors before sustainability

"Uncouple" Subcategories to fit "Rigid" Nine CERCLA Criteria







Regulatory Dilemma








Should we continue to try to clean up a potential groundwater resource when the remedy:

- creates significant air pollution and GHG
- consumes non-renewable resources
- creates new waste products
- creates collateral injury and death risks

Site CS-10, MMR Case Study








- Dilute TCE Plume
- 16 extraction wells pumping over 3700 gpm
- Treatment with GAC
- Reinjection of clean water into aquifer
- Pumping helps to protect a sole-source aquifer

Feasibility Study Alternatives








- Additional extraction well is needed to address off-site migration
- FS examined four alternatives for the main body of the plume*
  - No action - no land use controls
  - LTM - with land use controls
  - Status Quo Pumping (16 EWs /200+ MWs)
  - Add Extraction Well and Injection Well

* 6 additional alternatives were evaluated in a separate FS for leading edge

Sustainability Impacts Evaluated








- Air Emissions (vehicle use for sampling/maintenance, power use, carbon reactivation)
- Collateral Risks (drilling, sampling, transporting carbon, tick and insect disease)
- Solid Waste Generation (sampling, lab, treatment plant)
- Non-renewable resource loss (fuel, power)
- Other resource impacts (habitat and groundwater)

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Annual Sustainability Impacts of Alternatives Site CS-10, MMR

Alternative	Air	Air	Cancer Risks	Collateral Risks	Solid Waste	Resource Use	Resource Use	Additional Groundwater Degraded	
	GHG	VOCs	Lifetime Cancer	Injuries	Sludge	Fuel Use	Power Use	Additional Off Base Migration	
	Mton Per Year	Mton Per Year	Incidence	per year	CY/yr	gal/yr	kWhr	gallons	
No Action no LUCs	0	0	0.00034	0.000	0	0	0	1.5B	
LTM with LUCs	3	0	0.000001	0.022	78	263	0	1.5B	
Status Quo Pumping	1225	0.04	0.000001	0.025	97	626	1.6M	303M	
New Extraction Well	1235	0.04	0.000001	0.032	97	1586	1.6M	230M	

Life-Cycle Impacts








- Negative impacts of pumping alternatives:
  - 56,000 tons of GHG and 2 tons of VOCs to atmosphere (15,400 car-years)
  - Statistics estimate 1.9 injuries and 0.012 deaths from collateral risks
  - 73M kWhr used - enough to power 6900 homes for a year
- Positive impacts of pumping:
  - Prevents over one billion gallons of new gw contamination
  - Reduce 10^{-6} cancer risk for surface water exposure

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Hill AFB Environmental Sustainability Evaluation Tool








- Focused on four primary criteria:
  - Emission Intensity (EI)
    - Tons of GHG and criteria pollutants
  - Human Health Impacts (HHI)
    - Quantity (Qty) of injuries and fatalities
  - Material Intensity (MI)
    - Tons of non-recyclable waste generated
  - Non-renewable Energy Footprint (EF)
    - Tons of non-renewable fuel consumption
    - kWh of power consumption

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Hill AFB's eSeT








- Excel™-based calculator
- Database
  - Remediation system data input
  - Emission factors
  - Fuel efficiency
  - Published statistics
    - U.S. Department of Transportation (DOT)
    - Bureau of Labor
- Annual and Life Cycle Impact Estimator
- Summary Tables
  - Criteria totals
  - Total Environmental Sustainability Score
  - Sustainability Benefit:Cost Ratio

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eSeT Process








Data Entry

Table 10 - Greenhouse Gas Emission Factors

Energy Type	CO_2 Emission Factor	CO_2 Emission Factor Units	N_2O Emission Factor	N_2O Emission Factor Units	CH_4 Emission Factor	CH_4 Emission Factor Units	Average Miles Traveled/gallon of fuel consumed
Mobile Combustion							
Gasoline Passenger Cars	9.02	kg CO2/ gallon[3]	0.0816	grams/mile[3]	0.2173	grams/mile[3]	22.1
Gasoline Light-Duty Vehicles	9.02	kg CO2/ gallon[3]	0.1022	grams/mile[3]	0.2253	grams/mile[3]	17.6
Gasoline Heavy-Duty Vehicles	9.02	kg CO2/ gallon[3]	0.2361	grams/mile[3]	0.4345	grams/mile[3]	17.6
Diesel Passenger Cars	10.39	kg CO2/ gallon[3]	0.0161	grams/mile[3]	0.0161	grams/mile[3]	22.1
Diesel Light-Duty Vehicles	10.39	kg CO2/ gallon[3]	0.0322	grams/mile[3]	0.0161	grams/mile[3]	17.6
Diesel Heavy-Duty Vehicles	10.39	kg CO2/ gallon[3]	0.0483	grams/mile[3]	0.0966	grams/mile[3]	17.6
Gasoline Motorcycles	9.02	kg CO2/ gallon[3]	0.0073	grams/mile[3]	0.4184	grams/mile[3]	59
Diesel Ships and Boats	10.39	kg CO2/ gallon[3]	0.0377	grams/mile[3]	0.1058	grams/mile[3]	6.9
Gasoline Ships and Boats	9.02	kg CO2/ gallon[3]	0.0319	grams/mile[3]	0.0928	grams/mile[3]	6.9
Diesel Locomotives	10.39	kg CO2/ gallon[3]	91.52	grams/mile[3]	281.60	grams/mile[3]	0.003
Gasoline Agricultural Equipment	9.02	kg CO2/ gallon[3]	0.0297	grams/mile[3]	0.1703	grams/mile[3]	7.4
Diesel Agricultural Equipment	10.39	kg CO2/ gallon[3]	0.0351	grams/mile[3]	0.1946	grams/mile[3]	7.4
Gasoline Construction Equipment	9.02	kg CO2/ gallon[3]	0.0297	grams/mile[3]	0.0676	grams/mile[3]	7.4
Diesel Construction Equipment	10.39	kg CO2/ gallon[3]	0.0351	grams/mile[3]	0.0770	grams/mile[3]	7.4
Gasoline Snowmobiles	9.02	kg CO2/ gallon[3]	0.0044	grams/mile[3]	0.0100	grams/mile[3]	22.1
Gasoline Small Utility	9.02	kg CO2/ gallon[3]	0.0100	grams/mile[3]	0.0226	grams/mile[3]	22.1
Gasoline Heavy-Duty Utility	9.02	kg CO2/ gallon[3]	0.0100	grams/mile[3]	0.0226	grams/mile[3]	22.1
Diesel Heavy-Duty Utility	10.39	kg CO2/ gallon[3]	0.0115	grams/mile[3]	0.0258	grams/mile[3]	22.1

Emission Factor and Fuel Efficiency Database

Tabular Results

Alternative	Emission Intensity					Human Health Impacts (HHI)		Material Intensity		Non Renewable Energy Footprint			
	Greenhouse Gases[1] (tons CO_2 equivalent)	Passenger Car GHG Emission Equivalents[2]	Value on Chicago Climate Exchange (CCS)[3]	VOCs (tons)	SO_2 (tons)	Injuries	Fatalities	Waste (tons)	U.S. Personal Waste Generation Equivalents[4] (persons)	Fuel Consumption (tons)	Power Consumption (kWh)	U.S. Household Power Consumption Equivalents[5] (households)	Remediation Timeframe (yrs)
Alternative 1 - No Action	0	NA	NA	0	0	0	0	0	NA	0	0	NA	74
Alternative 2 - MNA and Institutional Controls	68	11	$304	0	0	0.23	0.030	0	NA	20	0	NA	74
Alternative 3 - MNA, Institutional Controls, and Contingent ISCO	210	35	$945	0.000048	0.0014	1.4	0.25	90	95	60	805	0.076	74
Alternative 4 - MNA, Institutional Controls, and Groundwater Extraction and Discharge	1,163	192			2	0.73	0.12	50	60	37	1,034,775	97	64

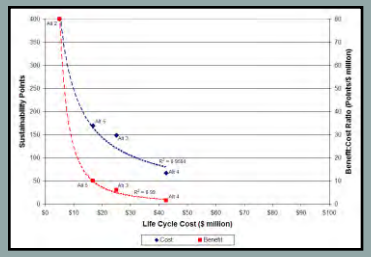


Table 9 - Life-Cycle Sustainability Criteria Scoring

Criteria	Emission Intensity	Human Health Impacts	Material Intensity	Non-Renewable Energy Footprint	Total Points	TOTAL SUSTAINABILITY SCORE	Total Life Cycle Present Worth Cost	Sustainability Benefit:Cost Ratio
Criteria Weight	25%	25%	25%	25%	100%		(million $)	(Points/million $)
Alternative 1 - No Action	N/A	N/A	N/A	N/A	N/A	N/A	$0	N/A
Alternative 2 - MNA and Institutional Controls	100	100	100	100	400	100%	$5.0	80
Alternative 3 - MNA, Institutional Controls, and ISCO	66	36	0	46	149	37%	$25.1	5.9
Alternative 4 - MNA, Institutional Controls, and Enhanced Aerobic Cometabolism	45	0	0	22	67	17%	$42.5	1.6
Alternative 5 - MNA, Institutional Controls, and Groundwater Extraction and Discharge	0	86	67	36	189	47%	$16.8	10

Summary & Graphics

Preliminary Life Cycle Comparison

Alternative	Emission Intensity (EI)			Human Health Impacts (HHI)		Material Intensity	Non Renewable Energy Footprint	
	Greenhouse Gases[1] (tons CO_2 equivalent)	VOCs (tons)	SO_2 (tons)	Injuries	Fatalities	Waste (tons)	Fuel Consumption (tons)	Power Consumption (kWh)
OU1 Trenches and Spring Collection	5,531	0.3	8.0	1.00	0.16	0	40	4,600,000
OU2 SRS, Spring Collection, G-Pool, UCS, NIT, and ASTP (without Steam Stripping)	4,191	0.2	5.6	0.90	0.14	27	41	3,240,000
OU8 BB Hydraulic Control System	2,816	0.1	4.0	0.90	0.15	300	22	2,297,449
OU8 1,2-DCA Extraction System	4,544	0.2	7.0	0.90	0.14	52	24	3,979,415
OU10 Shallow TCE Plume (MNA with contingent ISCO)	210	0.00005	0.0014	1.4	0.25	80	60	805
OU10 Deep TCE Plume (MNA with One Well Hydraulic Containment)	7,109	0	12	1.1	0.17	30	61	6,898,500
OU11 (MNA with SVE and Hydraulic Containment)	2,857	0.2	4.5	0.8	0.12	470	86	2,595,150

What Is Needed?








- Clear guidance on how to incorporate sustainability impacts such as greenhouse gas emissions into a CERCLA and RCRA remedy selection
- A method for replacing existing remedies with more sustainable solutions that have net positive environmental impacts
- A more comprehensive view of sustainability that considers collateral risks to workers and society on an equal par with cancer incidence risks

What Is Needed?








- Individual U.S. laws and regulations for the protection of soil, groundwater, and air are often self-serving without regard for net environmental benefit of a cleanup action. They need to be updated.

- Only valuable groundwater resources should require energy intensive treatments that negatively impact other parts of our biosphere. Producing tons of GHG to remove a few pounds of VOCs rarely makes sense.

- We must find ways to use solar and wind energy when valuable groundwater resources must be protected.

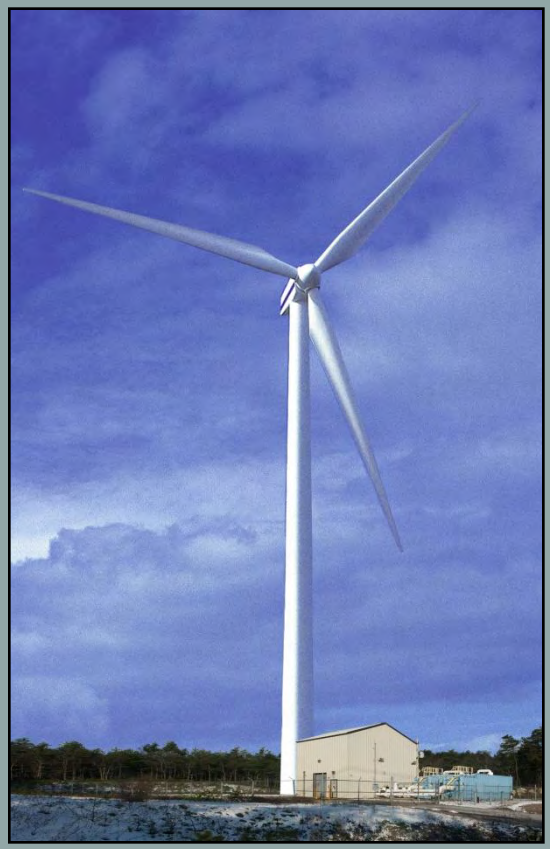
Lower Energy/Sustainable Remediation at MMR








- Completed Detailed Energy Audits
- Installed Variable Frequency Drive Pumps and saved $98K/year
- Replaced Sodium Vapor Overhead Lighting and saved $50K/year
- Elimination of Booster Pumps and Pump Motor Downsizing saved $45K/year
- Installation of 1.5 Megawatt Wind Turbine in 2009 will eventually power all pump and treat systems (CH2M HILL is providing design and Title II construction oversight)



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